What was that object? On the role of identity information in the formation of object files and conscious object perception

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Abstract

Object files are a psychological representation that allows the human brain to keep track of objects as they move and change across time. The question regarding what information is used to individuate versus update object files has been the focus of considerable scientific debate. Historically, the role of an object's spatiotemporal history was emphasised, whereas more recent work has demonstrated a key contribution from surface features, such as colour. The purpose of the present study was to investigate the role of *identity* level information in the formation and individuation of object files, and how it compares to the contribution of featural information. Using a modified spatial repetition-blindness paradigm, across four experiments, there was convergent evidence that surface features contribute to the formation of object files, whereas the role of identity information, was at best much smaller and less reliable than the clear contribution from surface features, and the most parsimonious explanation is that it was not present at all.

Keywords: object files; object perception; conscious perception; features; identity; repetition blindness; grouping

Visual scenes can be complex and dynamic, demanding rapid identification, tracking, and individuation of objects. For example, when driving along a busy street, there are different *types* of objects to recognise (cars, bikes, signs, pedestrians, and dogs running on the grass near the side of the road). One of the challenges for the human brain in such scenarios is to be able to keep track of an object despite potential changes in its appearance and location over time, and to distinguish these changes from the appearance of new objects entering the scene. The process of keeping track of an object over time is thought to be subserved by the visual-cognitive construct known as an *object file.* An object file is a temporary, episodic store, in which information about an object is updated as required. The purpose of the present paper was to examine the properties that influence the formation and individuation of object files.

Kahneman, Treisman, and Gibbs (1992) were the first to develop a behavioural paradigm to establish the presence of object files. These authors designed a few variants of the paradigm, but the major one goes like this: participants are presented with an array containing two letters sitting inside shapes (e.g., a ‘P’ inside a triangle and an ‘S’ inside a square). These appear a given distance directly above and below fixation. The letters disappear, and then the shapes are shown to move to new locations (locations a given distance directly to the left and right of fixation). This final presentation is the target display, in which a letter appears inside one of the shapes again. In the “Same Object” condition, the letter appears inside the shape that it did in the first array (e.g., ‘P’ inside triangle). In the “Different Object” condition, the letter that appears is one that was presented in the original array, but it now appears inside a different shape (e.g., ‘S’ inside triangle). Kahneman, Treisman, and Gibbs (1992) found a consistent reaction time (RT) advantage in identifying the target in the Same Object condition, compared with the Different Object condition. This is termed the object-specific preview effect. Importantly, this advantage cannot be attributed to a mere priming effect, since the letters in both the Same Object and Different Object conditions are repeated in both the first and second arrays. The key difference is instead the spatiotemporal history of the objects, and therefore whether or not the first and second presentation of the letter is consistent with it belonging to a continuous object.

While the object-specific preview effect is robust and compelling, it is one that focusses solely on response *efficiency* (i.e., RT). However, cognitive and perceptual psychologists have long been fascinated with understanding the mechanisms that underlie the formation of object representations that support *conscious object perception* (e.g., Alais & Lorenceau, 2002; Bouvier & Treisman, 2010; Goodhew, Dux, Lipp, & Visser, 2012; Hein & Cavanagh, 2012; Kanwisher, 1987; Lleras & Moore, 2003; Petersik & Rice, 2008; Treisman & Schmidt, 1982). That is, rather than just speeding or slowing a response to a stimulus, how do object files influence what is actually seen and what is not seen? Such conscious perception is inferred not from RT, but instead from participants' ability to detect or identify a stimulus on explicit report. One striking demonstration of this is repetition blindness (RB), the psychological process in which people fail to notice the repetition of items when the repetition occurs close in time. For example, when participants are presented with a rapid sequence of words and asked to report each of the words, they typically omit a repeated word, even if this violates the semantic structure of the sentence (Kanwisher, 1987, 1991). RB is a general phenomenon that occurs with a variety of stimuli, including words, non-words, letters, pictures, and colours (e.g., Bavelier, 1994; Goodhew, Greenwood, & Edwards, 2016; Kanwisher, Driver, & Machado, 1995; Morris & Still, 2008), and RB even occurs when the repeated items are presented simultaneously (spatial RB; Harris, Wong, & Andrews, 2015; Kanwisher et al., 1995; Luo & Caramazza, 1996).

According to the object-individuation hypothesis, RB reflects a failure to individuate separate tokens (i.e., object files) for multiple instances of the same type (Chun & Cavanagh, 1997; Coslett & Lie, 2008; Kanwisher, 1987; Kanwisher & Potter, 1989). This means, for example, that if presented with a series of objects such as *house, car, face, road, bike, car*, then one would encode the fact that the category *car* was present (type activation), but fail individuate and perceive both instances of the car (token individuation). Consistent with this account is the fact that the more episodically distinct the two repeated items are from one another (e.g., two letters presented in different colours), then the less likely RB is to be observed (Dux & Coltheart, 2008). This supports the type-token individuation account because episodic distinctiveness promotes the formation of unique object tokens, and therefore should protect against RB. Furthermore, RB is exacerbated under conditions of apparent motion (Chun & Cavanagh, 1997) and object-substitution masking (Goodhew et al., 2016) – both of which are characterised by continuing (updated) rather than individuated object tokens (Goodhew, 2017). An alternative account of RB has been proposed – that RB reflects the refractory period for a given type node (Luo & Caramazza, 1995, 1996). However, such a model is difficult to reconcile with the findings that even given the same temporal window between the repeated items, cues that promote distinctiveness and individuation affect the magnitude of RB.

Goldfarb and Treisman (2011b) found that perceptual grouping cues could mitigate spatial RB, and explained this within the type-token individuation framework. Specifically, these authors used spatially-adjacent colour as a grouping cue. Four coloured discs were presented simultaneously, arranged such that the repetition of colour was conducive to perceptual grouping, or was not (see Figure 1).

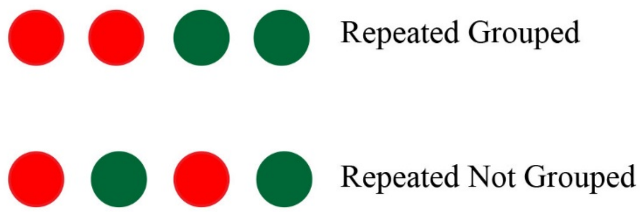

Figure 1. An illustration of the key conditions from Goldfarb and Treisman (2011b), where participants were presented with four discs, and asked to report the colour of each of the four

discs (from left to right). Superior performance was obtained where the repetition of the colour information allowed for grouping (Repeated Grouped, top row), compared with when repetition was present but did not facilitate grouping in the same way (Repeated Not Grouped, bottom row).

Participants' task was to identify each of the four colours. Even though both displays contained repetition and therefore should be conducive to RB, accuracy was greater when the arrangement facilitated colour-based perceptual grouping, compared with when it did not (Goldfarb & Treisman, 2011b). Goldfarb and Treisman suggested that "Grouping by color similarity is one principle (among many others) under which object files can be created. When grouped items are perceived as one object that contains multiple elements, the system simply identifies the grouped elements and the feature information once, for all of the elements together." (p. 1048). This means that in the case where the participant is presented with four discs in same-colour pairs (as per top row of Figure 1), it is likely that only two object files would need to be formed, one that contains the first two red discs, and one that contains the second two green discs. Goldfarb and Treisman (2011b) suggested that this would make these items easier to see, protecting them repetition blindness. To put this another way, the results suggest that colour is one feature that the visual-cognitive system uses in order to determine the formation and individuation of object files.

This question of what factors influence the formation of object files has resonated throughout the history of cognitive-psychological research on the spatial and temporal dynamics of conscious object perception. Interestingly, in the original influential paper on object files, Kahneman et al. (1992) were quite specific in what properties are important and those that are ignored in individuating versus updating object files: "Each object file is addressed by its location at a particular time, not by any feature or identifying label" (p. 178). A particularly notable aspect of this definition is that the object file can be de-coupled from featural changes in the object, and from knowledge about what the object is (i.e., object identity), so that this information can be updated over time. In other words, it is the object's spatiotemporal history that is paramount in determining its 'objecthood'. This argument has also been made by other researchers (e.g., Flombaum, Scholl, & Santos, 2009). However, a plethora of recent research has since demonstrated that an object's features do indeed influence whether updating or individuation of object files occurs, in addition to an object's spatiotemporal history (Goldfarb & Treisman, 2011a; Goodhew, 2017; Goodhew, Edwards, Boal, & Bell, 2015; Hein & Moore, 2012; Hollingworth & Franconeri, 2009; Kim, Jeng, & Anderson, 2013; Moore & Lleras, 2005; Moore, Stephens, & Hein, 2010; Richard, Luck, & Hollingworth, 2008). The results of Goldfarb and Treisman (2011b) are also consistent with the notion that surface feature properties influence the formation of object files.

Kahneman et al. (1992) emphasised that object files are independent of object identity information. However, it is worth revisiting this assumption. Identity information has obvious ecological validity (what an object *is* reflects a fundamentally important aspect of it, such as whether the orange object is a tiger or a fruit). While it is possible that such information is not available or used in the formation of object files and instead given priority at other stages of processing, it would seem an important principle to be entirely ignored at such a critical stage. Furthermore, identity-level information influences other visual-cognitive processes such as visual attention (Goodhew, Kendall, Ferber, & Pratt, 2014; Most, 2013; Wyble, Bowman, & Potter, 2009). It is therefore not inconceivable that it would affect object individuation processes. Finally, the question of how identity-level information influences object files was initially addressed by Gordon and Irwin (1996), and a recent study by Goldfarb and Sabah (2016) also speaks to this issue. Gordon and Irwin (1996) used a variant of the object-specific preview paradigm originally developed by Kahneman et al. (1992), and found evidence to suggest that identity-level information was encapsulated in object files. Similarly, Goldfarb and Sabah (2016) also found evidence to suggest that identity information influenced object file formation. However, both of these studies were limited to showing response efficiency effects, and did not demonstrate actual perceptual effects. The purpose of the present study, therefore, was to extend on this by examining whether identity-level information affects the formation of object files to the extent that this influences an observer's conscious experience of the visual display, and how this compares with the contribution of surface features to this process. This can be inferred from the objects that they report and those that they either fail to report or misreport.

EXPERIMENT 1

For the present study, Goldfarb and Treisman's (2011b) paradigm was adapted to examine the role of identity-level information in the formation of object files. Word stimuli of different cases instead of coloured discs were used (e.g., 'BLUE' and 'blue'), because such stimuli are linked at an identity level but are not physically identical. That is, a commonly-used method to isolate the contribution of identity from surface features is to employ letter or word stimuli that have the same identity, but differ with respect to their case (Clay, Bowers, Davis, & Hanley, 2007; Goodhew et al., 2016; Marohn & Hochhaus, 1988; Parasuraman & Martin, 2001; Shapiro, Driver, Ward, & Sorensen, 1997). This approach was used here, however, as subsequent experiments will reveal, the assumption that different case eliminates all featural processing is potentially problematic. However, the predictions for this experiment were that if identity-level information is stored in object files, then there should be an advantage in perception and therefore report-accuracy when two items of the same identity are adjacent to one another, compared with when two items of the same identity appear in the same display but are separated by an intervening item.

Method

Participants

All participants in this and the following experiment provided written informed consent prior to participation and received course credit or cash in exchange for their participation. The experimental protocol was approved by the ANU Human Research Ethics Committee. Goldfarb and Treisman (2011b) tested 6 participants on 64 experimental trials. For the present experiments, therefore, a larger number of participants and trials were included to ensure adequate power. A sample size of 20 participants was chosen and the number of trials always exceeded 64.

A total of 20 participants were recruited via the Australian National University's (ANU) research participation website. The mean age of participants was 20.70 years (SD = 2.74). Fifteen were female and 5 were male, and all but two reported being right-handed, with the others reporting being left-handed.

Stimuli & Procedure.

The stimuli were the words 'PINK' and 'BLUE' presented in black on a mid-grey background screen. The words were presented in size 18 *Courier New* font at a viewing distance of approximately 44 cm. On each trial, four words were presented on the same horizontal meridian. Each word could appear in upper or lower case. The precise arrangement and number of the words depended on which condition the trial belonged to. In the key Adjacent Repetition condition, the items consisted of two pairs of immediately adjacent repeated items (i.e., no intervening items, e.g., PINK pink BLUE blue). In this condition, case always alternated between uppercase and lowercase (or vice versa) from one item to the next moving from left to right across the display. This means that the repeated items were not in the same case and thus not physically identical, instead they were linked in terms of word meaning. In this and all subsequent conditions, all possible arrangements of word placement and order, while meeting the above constraints, were used (here four possible arrangements: PINK pink BLUE blue / pink PINK blue BLUE / BLUE blue PINK pink / blue BLUE pink PINK).

Performance in the Adjacent Repetition condition was compared against a baseline in which repetition occurred, but the two repeated items were separated by an intervening item. In this Separated Repetition condition, the two repeated items were different cases (as per the Adjacent Repetition condition). Case for the first two items always varied, resulting in four possible sequences (PINK blue pink BLUE / pink BLUE PINK blue / BLUE pink blue PINK / blue PINK BLUE pink). If the formation of object files is influenced by identity-level information, then there should be the same perceptual report advantage in the Adjacent Repetition condition as Goldfarb and Treisman (2011b) observed with coloured discs. In contrast, if the formation of object files is influenced by low-level features such as colour but not identity-level information, then no such advantage should be seen.

Table 1. Example displays for each of the five conditions in Experiment 1. Note, however, that it is the comparison of the Adjacent Repetition and Separated Repetition conditions that is key.

Name of Condition	**Example Display**
Adjacent Repetition	PINK pink BLUE blue
Separated Repetition	pink BLUE PINK blue
Same Case Separated Repetition	BLUE pink BLUE pink
Triple Repetition	pink PINK pink BLUE
Mixed Repetition	blue PINK pink BLUE

Several filler conditions (see Table 1) were included to discourage participants from adopting any unintended strategies for identifying conditions and therefore target identities. Specifically, the Same Case Separated Repetition condition was similar to the Separated

Repetition condition, except that the two repeated items appeared in the same case (i.e., physically identical). In the Triple Repetition condition, three instances of a given colour word were presented with one instance of the other colour, and in the Mixed Repetition condition, both adjacent and separated repetition was present.

On each trial, the four words were presented simultaneously for 267 ms, with the array centred on the centre of the screen. Then the screen was blank for 133 ms, following which response prompts appeared sequentially for each of the words (e.g., ‘Word 1?). Participants were instructed to identify each of the four words that had been presented, starting with the left-most word, followed by the second from the left, and so on for the four words. In order to identify each word, they were told to press the ‘b’ key to identify the word *blue*, and press the ‘p’ key to identify the word *pink* (irrespective of case). After the four responses were registered, the screen was blank for a 1000 ms inter-trial-interval. The experiment consisted of 168 trials, with each condition being equi-probable. Participants completed a 12-trial practice block with corrective feedback to familiarise them with the task prior to completing the experiment. They were required respond correctly for 62.5% of keypresses or greater in order to progress to the experiment proper (repeated as necessary). Participants completed all components of the task in 15 minutes or less.

Results & Discussion

Trials were screened to determine if participants made any invalid responses (i.e., they pressed a key other than one of the designated response keys), and these trials were excluded from further analysis. Such instances were exceedingly rare (occurred on 0.6% of trials for 4 participants, and 0% of trials for the other 16 participants). The score for each trial was calculated by summing a 25% portion for each of the four words per trial that were correctly reported in order (e.g., a participant would score 75% for a trial if correctly reported three of the four words on that trial). Average accuracy for each condition was then computed by taking mean performance across trials for that condition. Data from one participant was excluded from further analysis due to poor accuracy (i.e., <55%, where chance is 50% in this experiment). Proportion correct for each condition averaged across the remaining 19 datasets is shown in Figure 2.

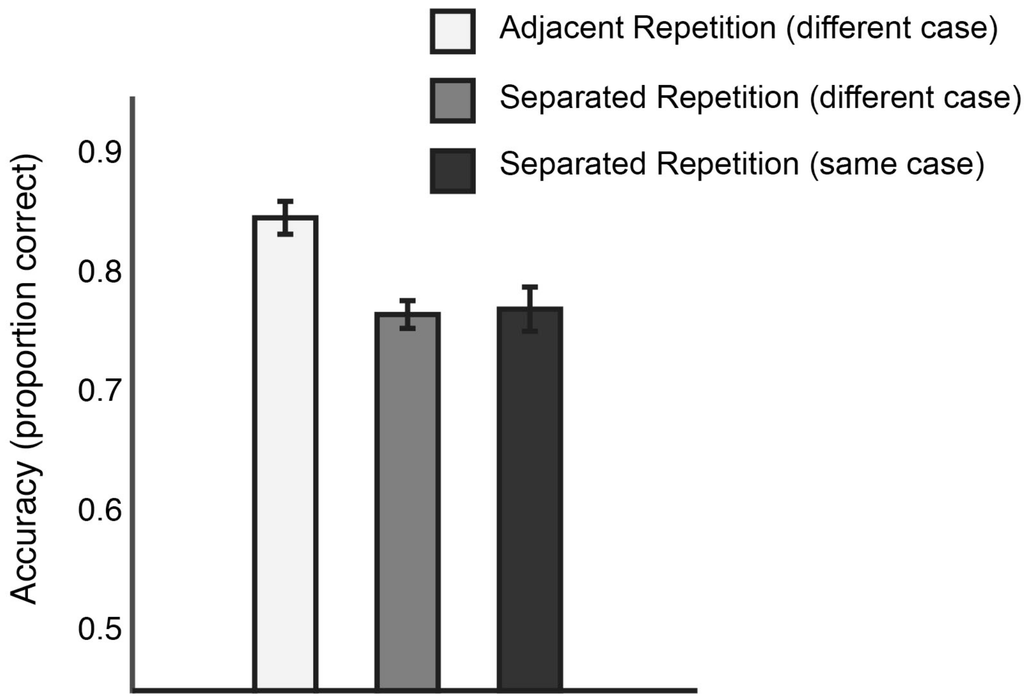

Figure 2. An illustration of the average (proportion correct) accuracy in the Adjacent Repetition and Separated Repetition conditions in Experiment 1. Note that the graph is cut-off at chance-level performance on the y-axis, rather than zero. Error bars depict standard errors of the mean corrected for within-subjects designs (Cousineau, 2005).

A repeated measures *t*-test revealed that, as can be seen in Figure 2, average accuracy in the Adjacent Repetition condition (M = .84) significantly exceeded that of the Separated Repetition condition (M = .76), $t(18) = 4.64$, $p < .001$. These results show that spatially-adjacent repetition of identity information results in superior performance than separated repetition. This suggests that identity-level information can influence the formation of object files.

Furthermore, while the comparison between the Adjacent Repetition and Separated Repetition conditions was the focus of the study, if identity-level information is influencing the formation object files, then the Same Case Separated Repetition condition should also produce lower levels of performance than the Adjacent Repetition condition. This was indeed the case (Adjacent Repetition = .84; Same Case Separated Repetition = .77, p = .022). This indicates that repetition of the identical physical form did not facilitate performance over same-identity but different physical form items, when these were not adjacent to one another.

To summarise, the results of Experiment 1 appear to suggest that identity-level information can contribute to the formation of object files. However, several outstanding questions remain. First and foremost, in Experiment 1, the number of stimuli used throughout the experiment was relatively small – just two different words, resulting in four different stimuli (`PINK, BLUE, pink, blue, here shown in Courier New Font as they were displayed in`). This may have facilitated the adoption of a strategy of focussing on the *features* that differentiated the different word stimuli, and participants could have used these to respond, rather than truly processing the identity of the word. For example, with the lowercase stimuli, they could recognise the shape of the word, such that if it is lowercase and has a stroke below the main baseline of the font (i.e., a “descender” on the letter *p*), then it is *pink*, whereas if it is lowercase but has ascenders above the main baseline of the font (due to the *b* and/or the *l*), then it is *blue*. Although uppercase stimuli do not have differentiating ascenders and descenders like lowercase font, since there were so few candidate stimuli that could be presented on a given trial, there are still some featural differences between the shapes of the words to which participants may have become attuned. For example, it would be possible to differentiate between PINK and BLUE by identifying whether there was one versus two curvature angles in the first letter. Alternatively, participants could have adopted a single strategy for both uppercase and lowercase words, such as focussing on the particular angular shape of the letter 'k' which is present in both its uppercase and lowercase forms, and the presence of this shape at the end of the word would have signalled that the correct response to the item was pink, and its absence that the correct response was blue.

Thus, the possibility that participants were adopting feature-based strategies to perform the task in Experiment 1 cannot be ruled out. This means that the apparent advantage for the Adjacent Repetition condition could have been a product of one of these strategies, rather than a consequence of identity truly contributing to the formation of object files. Experiment 2 sought to address this possibility by increasing the number of candidate stimuli.

Second, Experiment 1 did not include a 'no repetition' baseline condition against which to gauge patterns of impairment versus facilitation in the repetition conditions. Therefore, it is unclear whether the pattern of results reflects degrees of repetition blindness, its elimination, or indeed repetition priming. This was rectified in Experiment 2 by the inclusion of a no-repetition baseline. Third, while in the Adjacent Repetition condition in Experiment 1 the critical items were in different cases, the design did not permit comparison of the role of identity versus featural contributions to the beneficial effect of adjacent repetition to perception. Experiment 2 addressed this by varying these factors independently.

EXPERIMENT 2

Experiment 2 was designed to address three outstanding issues from Experiment 1. An additional target word was added to increase the number of candidate stimuli: `gold / GOLD`. This means that feature-based strategies such as identifying the presence of a descender on the lowercase items, counting the number of curvatures, or looking for the presence or absence of the letter *k* at the end of the word would all no longer suffice for identifying the target. This permitted a stronger test of the role of identity versus features in protecting against repetition blindness. Furthermore, a no-repetition baseline condition was included in this experiment in order to gauge repetition blindness, which should be exhibited as impaired accuracy relative to a no-repetition baseline. In order to facilitate this, the number of items presented on each trial was reduced from four to three. This is because, for the sake of consistency, the items *pink* and *blue* ought to be included in Experiment 2. Additional items should be drawn from the same conceptual category (i.e., colour words), as it is conceivable that crossing category boundaries may produce different patterns of results. The additional items need to have the same number of letters, such that the length of the word is not a cue to its identity. The number of four-letter colour-words to select from is relatively small, and many other candidates had potential issues. Words such as *aqua* and *navy* have conceptual overlap with *blue*, and therefore it was unclear whether this would unduly impact the results (e.g., *navy* and *blue* may have been conceptually grouped, even though they were defined as different-identity items). The background was grey, and therefore having *grey* as a target word could have led to conflict between the perceived grey of the background and the processing of the word *grey*. Other candidate colour words are lower frequency and have lower recognisability, such as *puce*. Altogether, this led to the decision to add just one additional target word (*gold*), and instead the number of items presented on each trial was reduced to three, thus allowing for the inclusion of a condition in which no repetition of target identity occurred.

Finally, when items appear in the same case, while they share identity, they are featurally identical, and therefore any observed effects may be entirely due to this featural match. In contrast, it is only when they appear in different cases that the featural link is weakened and the role of identity-level grouping is strongly tested. While in Experiment 1 the critical Adjacent Repetition condition entailed stimuli that appeared in different cases, in

Experiment 2, case-match and identity-match were factorially varied. This allowed a fuller assessment of the role of features versus identity in their contribution to repetition blindness and protection from it.

If identity can facilitate the grouping of items into a single object file to protect against repetition blindness, then adjacent repetition of identity, irrespective of case, should produce increased performance relative to the separated repetition of identity (i.e., when repetition is present in the display but does not enjoy the benefit of being adjacent). If identity does not facilitate grouping and instead featural similarity does, then only adjacent repetition for same-case and not different-case items should produce increased performance relative to the separated repetition of identity. Moreover, performance in the separated repetition condition should be lower than the no-repetition baseline, indicative of repetition blindness. If the protective effect of adjacent repetition is strong, then performance in this condition should be equivalent to the no-repetition baseline.

Method

Participants.

A total of 20 participants were recruited. Participants' mean age was 20.70 years (SD = 2.15). Fourteen were female and 6 were male, and all but three reported being right-handed, with the others reporting being left-handed.

Stimuli & Procedure.

The stimuli were the words 'PINK', 'BLUE', and 'GOLD' presented in black on a mid-grey background screen. The additional word *gold* was added compared to Experiment 1, and the number of words shown on each trial reduced from four to three. These changes were made in order to allow for a no-repetition baseline condition, while satisfying the constraints of: (a) using the same words as Experiment 1 (*pink* and *blue*), without crossing a category boundary (i.e., the words were still colour words), and (b) allowing all of the words to have four letters, such that length was not a cue to identity.

The words were presented in size 18 *Courier New* font at a viewing distance of approximately 60 cm. On each trial, three words were presented separated from left to right. Each word could appear in upper or lower case. The precise arrangement and number of the words depended on which condition the trial belonged to. In the Repeated-Adjacent conditions, the repetition of the word was adjacent (i.e., the first two of the three items had the same identity). In the Repeated-Adjacent-Same-Case condition, these two items were the same case, whereas in the Repeated-Adjacent-Different-Case condition, they were in different cases. For both conditions, the third word was always a different identity relative to the first two. To ensure that there was always heterogeneity of case across the array, the case of the third item in the Repeated-Adjacent-Same-Case condition was always different to the two preceding items. For the Repeated-Adjacent-Different-Case condition, the third item was the same case as the second item (see Table 2).

In the two Separated Repetition conditions, the repetition appeared for the items in the first and third positions (i.e., the repetition was separated by an intervening item). For the Separated-Repetition-Same-Case condition, the two repeated items appeared in the same case (such that case alternated across the display), whereas for the Separated-Repetition-Different-Case condition, the two repeated items appeared in different cases, with the case of the second item matching the third. In the two No Repetition conditions, no item was repeated. For the No-Repetition-Same-Case condition, the first two items had the same case (as per the Adjacent Repetition-Same-Case condition), whereas for the No-Repetition-Different-Case condition, the first two items were different case.

Table 2. Example displays for each of the six conditions in Experiment 2. Note that all three words (*pink, gold,* and *blue*) were used as stimuli on different trials in all conditions. The case of first item was equally likely to be upper versus lower case for all conditions.

Name of Condition	**Example Display**
Adjacent Repetition Same Case	PINK PINK gold
Adjacent Repetition Different Case	PINK pink gold
Separated Repetition Same Case	PINK gold PINK
Separated Repetition Different Case	PINK gold pink
No Repetition Same Case	PINK GOLD blue
No Repetition Different Case	PINK gold BLUE

In the present study, if the formation of object files is influenced by identity-level information, then there should be a perceptual report advantage in the Adjacent-Repetition-Different-Case condition relative to the Separated Repetition condition, since this is the condition where the first two repeated items are linked by identity but not features. In contrast, if the formation of object files is influenced by low-level features and not identity-level information, then an advantage should be observed only in the Adjacent-Repetition-Same-Case condition, where the first two items are linked by low-level features, and no advantage should be apparent for the Adjacent-Repetition-Different-Case condition.

On each trial, the four words were presented simultaneously for 200 ms, with the array centred on the centre of the screen. Then the screen was blank for 133 ms, following which response prompts appeared sequentially for each of the words (e.g., ‘Word 1?). Participants were instructed to identify each of the three words that had been presented, starting with the left-most word, followed by the middle word, and then the word on the right. In order to identify each word, they were instructed to press the ‘z’ key to identify the word *pink*, and press the ‘x’ key to identify the word *blue*, and the ‘space bar’ to identify the word as *gold* (irrespective of case). After the three responses were registered, the screen was blank for a 1000 ms inter-trial-interval. The experiment consisted of 120 trials, such that there were 20 trials in each condition. Participants completed a 12-trial practice block with corrective feedback to familiarise them with the task prior to completing the experiment. They were required respond correctly for 62.5% of keypresses or greater in order to progress to the experiment proper (repeated as necessary). Participants completed all components of the task in 15 minutes or less.

Results & Discussion

Trials were screened for invalid responses (<1% for one participant, 0% for all others), which were removed from the analysis. The score for each trial was calculated by summing a one-third portion for each of the three words per trial that were correctly reported in order. Average accuracy for each condition was then computed by taking mean performance across trials for that condition. Proportion correct for each condition averaged across the 20 datasets is shown in Figure 3.

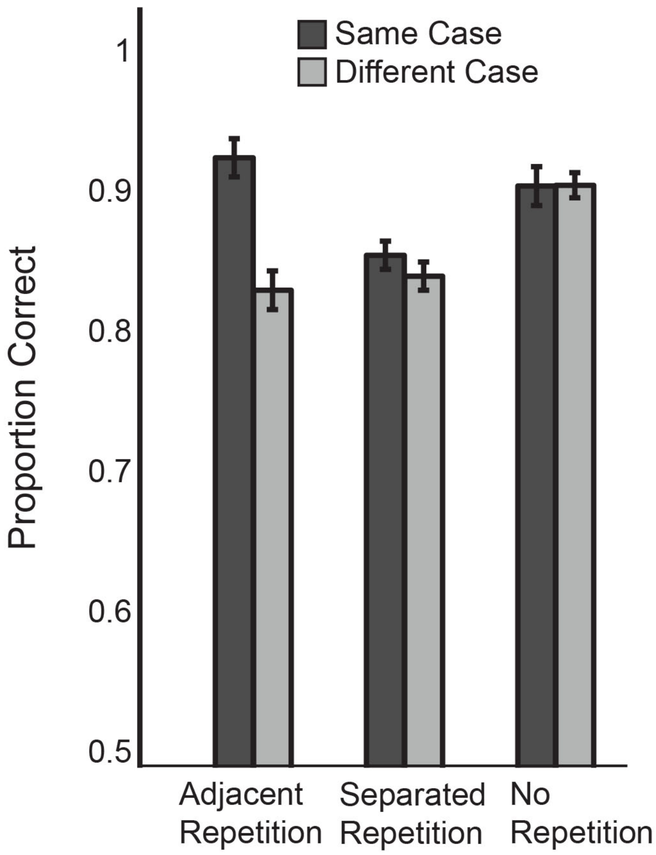

Figure 3. An illustration of the average accuracy (proportion correct) in the six conditions in Experiment 2. Note that the graph is cut-off at 0.5 on the y-axis, rather than zero. Error bars depict standard errors of the mean corrected for within-subjects designs (Cousineau, 2005).

The accuracy data for each condition were submitted to a repeated-measures ANOVA with one variable (condition) with six levels. Mauchly's test indicated that sphericity was violated ($p = .021$), and therefore the Greenhouse-Geisser correction was applied. The ANOVA indicated a significant effect of condition, $F(3.68, 69.96) = 9.20$, $p < .001$, $\eta_p^2 = .326$. This indicates that performance varied across the six conditions. To understand this further, the Adjacent Repetition and Separated Repetition conditions were submitted to a 2 (repetition condition: adjacent versus separated) x 2 (case: same versus different) factorial ANOVA. This revealed a non-significant effect of repetition condition, $F(1, 19) = 3.75$, $p = .068$, $\eta_p^2 = .165$, and a significant main effect of case, $F(1, 19) = 23.16$, $p < .001$, $\eta_p^2 = .549$, such that proportion correct was greater when case matched (M = .89) than when it mismatched (M = .83). However, these main effects were qualified by a significant interaction between repetition condition and case, $F(1, 19) = 12.01$, $p = .003$, $\eta_p^2 = .387$. Repeated measures *t*-tests revealed that, as can be seen in Figure 3, proportion correct was significantly greater in the Adjacent-Repetition-Same-Case condition (M = .92) than in the Adjacent-Repetition-Different-Case condition (M = .83), $t(19) = 4.50$, $p < .001$, whereas there was no significant difference between the Separated-Repetition-Same-Case condition (M = .85) and the Separated-Repetition-Different-Case condition (M = .84), $t(19) = 1.65$, $p = .115$.

Next, it is important to compare performance in these conditions against the No Repetition baseline. A repeated-measures *t*-test confirmed that performance did not differ as a function of case in the No Repetition condition ($p = .968$). Therefore, the mean of these two conditions was used as the No Repetition baseline. Indeed, performance in the Adjacent-Repetition-Same-Case condition was equivalent to the No-Repetition baseline ($p = .304$), whereas performance in the other three conditions each fell below the No-Repetition baseline (*p*s < .006). This indicates the repetition blindness repetition was present (i.e., a decrement in performance due to the presence of repetition), except in the Adjacent-Repetition-Same-Case condition, where it was mitigated to the extent that performance was indistinguishable from when repetition was absent. This pattern of performance is indicative of featural similarity rather than identity-level information contributing to the formation of object files.

The results of Experiment 2 supported the notion that features but not identity facilitate grouping in repetition blindness. Experiment 1 provided evidence that could potentially reflect identity-level processing, but in light of Experiment 2, it is possible that this was actually featural processing masquerading as identity-level processing. That is, it was reasoned that the pattern of results in Experiment 1 might instead reflect some featural similarity facilitating performance for items that had the same identity, even when they appeared in different cases (e.g., *pink* is somewhat similar to *PINK*). Indeed, feature-similarity is likely to operate on a graded basis, with some items being more similar and therefore facilitating performance to a greater extent than others. If so, then there might be something particularly featurally similar about the uppercase and lowercase versions of the items used in Experiment 1. On the face of it, the items *pink/PINK* appear to have much featural overlap, less than say *gold/GOLD*. The data in Experiment 2 actually provides a way of checking this. In Experiment 2, there was just one instance of repetition on each trial when repetition was present. This provides the opportunity to analyse performance as a function of which target word was repeated. Specifically, performance in the Adjacent Repetition Different Case condition of Experiment 2, where adjacent items had the same identity but different cases, was assessed as a function of which item was the target. Performance in the Adjacent Repetition Different Case was greatest when the repeated target word was *pink/PINK* (M = .89), and lowest when the repeated target word was *gold/GOLD* (M = .79). This difference was significant (p = .009). The trials where the repeated target was the word *blue/BLUE* produced an intermediate level of performance (M = .83), which was marginally significantly worse than *pink/PINK* (p = .054), and not reliably different from *gold/GOLD* (p = .277). In other words, the uppercase and lowercase pink items are quite similar to one another. In particular, the *pink/PINK* items produced a level of performance that was equivalent (p = .204) to the Adjacent Repetition Same Case condition, where the items were featurally identical, whereas both the *blue/BLUE* (p = .002) and *gold/GOLD* (p = .004) produced demonstrably worse performance than that condition.

Altogether, this analysis of the Adjacent Repetition Different Case condition of Experiment 2 indicated that performance changed as a function of which item was repeated, which is suggestive of the items having different levels of featural similarity between their uppercase and lowercase versions. This led to the motivation for Experiment 3. Given this analysis, if the results of Experiment 1 are the product of featural similarity rather than identity processing, then it should be possible to repeat the design of Experiment 1, but to weaken the apparent advantage for the different-case items by changing the target items, in particular, by eliminating the item *pink/PINK*.

EXPERIMENT 3

The results of Experiment 2 supported a different conclusion compared with that from Experiment 1. That is, while the results of Experiment 1 appeared to provide evidence that identity-level information is consulted in the formation of object files, Experiment 2 instead suggested that featural but not identity-level information is used. It was hypothesised that this was a consequence of the fact that in Experiment 1, the small number of candidate target items may have promoted feature-level processing, which facilitated performance even when the items were not featurally identical, but shared some featural similarity across different-case versions of the same word. If so, then this undermines any support for purported identity-level processing from Experiment 1. Moreover, a post-hoc analysis of the data in Experiment 2 suggested that when adjacent items were of different case, performance scaled as a function of similarity between the uppercase and lowercase versions of the repeated word. Given this, in Experiment 3, the design of Experiment 1 was repeated, but now the highly similar item *pink/PINK* was eliminated. If the results of Experiment 1 do reflect featural-processing facilitating performance in the condition designed to gauge identity-level processing, then the advantage for this condition should be weakened or eliminated by removing the target word *pink/PINK,* which the data from Experiment 2 indicated was the most featurally-similar item in its lowercase and uppercase forms.

Method

Participants

A total of 20 participants were recruited. Their mean age was 22.45 years (SD = 4.27). Sixteen were female and 4 were male, and all but one reported being right-handed, with the others reporting being left-handed.

Stimuli & Procedure

The stimuli were the words ‘BLUE’ and ‘GOLD’ presented in black on a mid-grey background screen. The words were presented in size 18 *Courier New* font at a viewing distance of approximately 60 cm. On each trial, four words were presented on the same horizontal meridian. Each word could appear in upper or lower case. The precise arrangement and number of the words depended on to which condition the trial belonged. In the key Adjacent Repetition condition, the items consisted of two pairs of immediately adjacent repeated items (i.e., no intervening items, e.g., GOLD gold BLUE blue). In this condition, case always alternated between uppercase and lowercase (or vice versa) from one item to the next moving from left to right across the display. This means that the repeated items were not in the same case and thus not physically identical, instead they were linked in terms of word meaning. In this and all subsequent conditions, all possible arrangements of word placement and order, while meeting the above constraints, were used.

Performance in the Adjacent Repetition condition was compared against a baseline in which repetition occurred, but the two repeated items were separated by an intervening item. If the formation of object files is influenced by identity-level information, then there should be a perceptual report advantage in the Adjacent Repetition condition relative to the two separated repetition conditions. In contrast, if the formation of object files is influenced by low-level features but not identity-level information, then no such advantage should be seen.

Table 4. Example displays for each of the five conditions in Experiment 3.

Name of Condition	Example Display
Adjacent Repetition	GOLD gold BLUE blue
Separated Repetition	GOLD blue gold BLUE
Same Case Separated Repetition	GOLD blue GOLD blue
Triple Repetition	GOLD gold GOLD blue
Mixed Repetition	blue GOLD gold BLUE

Several filler conditions (see Table 4) were included to discourage participants from adopting any unintended strategies for identifying conditions and therefore target identities. These followed the same constraints as those used as Experiment 1. On each trial, the four words were presented simultaneously for 267 ms, with the array centred on the centre of the screen. Then the screen was blank for 133 ms, following which response prompts appeared sequentially for each of the words (e.g., 'Word 1?). Participants were instructed to identify each of the four words that had been presented, starting with the left-most word, followed by the second from the left, and so on for the four words. In order to identify each word, they were told to press the 'z' key to identify the word *gold*, and press the '/?' key to identify the word *blue* (irrespective of case). After the four responses were registered, the screen was blank for a 1000 ms inter-trial-interval. The experiment consisted of 168 trials, with each condition being equi-probable. Participants completed a 12-trial practice block with corrective feedback to familiarise them with the task prior to completing the experiment. They were required respond correctly for 67% of keypresses or greater in order to progress to the experiment proper (repeated as necessary).

Results & Discussion

Trials were screened to determine if participants made any invalid responses (i.e., they pressed a key other than one of the designated response keys), and these trials were excluded from further analysis. Such instances were exceedingly rare (occurred on <0.05% of trials for 3 participants, and 0% of trials for the other 17 participants). The score for each trial was calculated by summing a 25% portion for each of the four words per trial that were correctly reported in order. Average accuracy for each condition was then computed by taking mean performance across trials for that condition. Proportion correct averaged across the 20 datasets is shown in Figure 4.

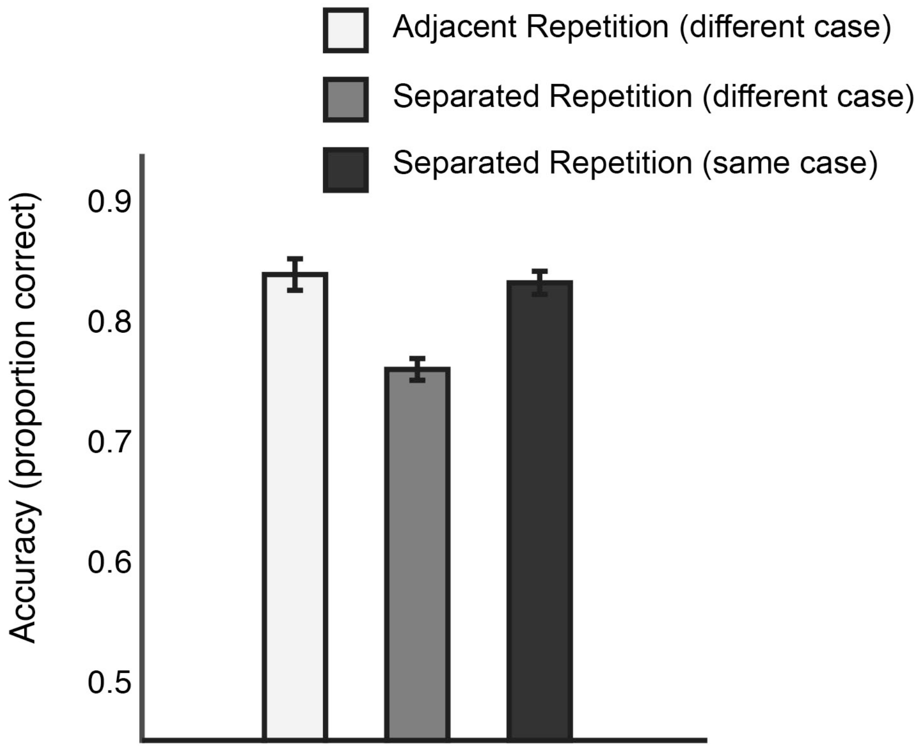

Figure 4. An illustration of the average (proportion correct) accuracy in the Adjacent Repetition and Separated Repetition conditions in Experiment 3. Note that the graph is cut-off at chance-level performance on the y-axis, rather than zero. Error bars depict standard errors of the mean corrected for within-subjects designs (Cousineau, 2005).

A repeated measures *t*-test demonstrated that average accuracy in the Adjacent Repetition condition (M = .84) significantly exceeded that of the Separated Repetition condition (M = .76), $t(19) = 3.88$, $p < .001$. However, the Same Case Separated Repetition condition produced performance equivalent to that of the Adjacent Repetition condition (Adjacent Repetition = .84; Same Case Separated Repetition = .83, $p = .750$), and performance in the Same Case Separated Repetition condition was significantly higher than the Separated Repetition condition (.76, $p < .001$).

The advantage for the Adjacent Repetition condition would appear to suggest that identity-level information may have been processed in this experiment. However, this evidence is undermined by the fact that one of the Separated Repetition conditions performed equally well. In this condition, adjacent items do not have the same identity, and so an identity-processing based explanation cannot explain this advantage.

Instead, one possibility is that both the Adjacent Repetition and Same Case Separated Repetition conditions enjoyed an advantage because they shared a common format of case in the display (i.e., alternating case), which was not shared with the relatively disadvantaged Separated Repetition (different case) condition. That is, the Same Case Separated Repetition condition never had stimuli of the same case appearing next to one another – which was also true of the Adjacent Repetition condition. In contrast, the Separated Repetition (different case repetition) condition did have items of the same case appearing next to one another. It is therefore possible that avoiding adjacent repetition of case facilitated performance in both of these conditions *irrespective of identity* – an effect which would be unambiguously attributable to feature-level processing. Regardless, the fact that with these different target stimuli, the Adjacent Repetition condition did not perform consistently superior to the two conditions with separated repetition means that there was no unambiguous evidence for identity-level information facilitating performance in Experiment 3, and suggests that the results of Experiment 1 likely reflected residual featural rather than identity-level processing.

To summarise, the results of Experiment 3 found no compelling evidence that identity-level information contributed to the formation of object files.

EXPERIMENT 4

Finally, Experiment 4 was conducted to confirm the robustness of the conclusion so far: that features but not identity contributes to the formation of object files in repetition blindness. In particular, Experiment 4 sought to provide a definitive test of identity, completely independent of any contribution from featural similarity. To this end, different format stimuli were used that could be linked in terms of identity, but not at all in terms of low-level features – coloured discs and colour-words. For example, the word 'GREEN' and a green disc are *only* linked in terms of identity, and not features. The same conditions as Experiment 2 was employed, except for the addition of some extra conditions in order to assess how different the formats of the stimuli affected performance.

Participants

Twenty participants were recruited for Experiment 4. Their mean age was 22.05 years (SD = 4.03). Thirteen were female and 7 were male, and all but three reported being right-handed, with the others reporting being left-handed (two) or ambidextrous (one).

Stimuli & Procedure

The stimuli were the words 'GREEN', 'BROWN, 'WHITE', and 'LILAC', and green, brown, white, and lilac coloured discs presented in black on a mid-grey background screen. The words were presented in size 18 *Courier New* font at a viewing distance of approximately 60 cm. The discs each subtended approximately .58 degrees of visual angle. On each trial, four items (a combination of words and discs) were presented separated from left to right. The words always appeared in uppercase. All arrays contained two coloured discs and two words. The precise arrangement of the words and discs depended on which condition the trial belonged to (see Table 3). In the two Adjacent Repetition conditions, the first pair of items and the second pair of items were the same identity (i.e., A A B B). The difference between the two conditions was whether or not the same identity items appeared in the same format (i.e., both discs or both words; Adjacent Repetition Same Format condition), or different format (i.e., one disc and one word; Adjacent Repetition Different Format).

In the three Separated Repetition conditions, the repetition of identity was separated by an interleaving identity (i.e., A B A B). The difference between the Same and Different format conditions was whether or not the repeated same identity items appeared in the same format (Separated Repetition Same Format) or different format (Separated Repetition Different Format). Furthermore, there were two versions of the Separated Repetition Different Format conditions, one where the items were arranged such that the inner two items had the same format as each other, and the outer two items had the other format (Separated Repetition Different Format A), and the other where the items were arranged such that the first pair of items had the same format, and the second pair had the other format (Separated Repetition Different Format B). Finally, there were three No Repetition conditions, in which the same identity was never repeated. This means that all identities (green, brown, white, lilac) all appeared in the array in some format. In the No Repetition Format A condition, the first and third items had the same format, and then the second and fourth the other format. In the No Repetition Format B condition, the first pair of items had the same format, and then the second pair another format. In the No Repetition Format C condition, the outer items had the same format, and then the inner two items had the same format.

On each trial, the four items were presented simultaneously for 267 ms, with the array centred on the centre of the screen. Then the screen was blank for 133ms, following which response prompts appeared sequentially for each of the items (e.g., ‘Item 1?). Participants were instructed to identify each of the items that had been presented, starting with the left-most item, and moving toward the right. In order to identify each item, they were instructed to press the ‘z’ key to identify a green item, press the ‘x’ key to identify a brown item, press the ‘.>’ key to identify a white item, and press the ‘/?’ key to identify a lilac item (irrespective of format – word or disc). After four responses were registered, the screen was blank for a 1000 ms inter-trial-interval. The experiment consisted of 240 trials, such that there were 30 trials in each condition. Participants completed a 16-trial practice block with corrective feedback to familiarise them with the task prior to completing the experiment. They were required respond correctly for 62.5% of keypresses or greater in order to progress to the experiment proper (repeated as necessary). Participants completed all components of the task in 30 minutes or less.

Table 3. Example displays for each of the eight conditions in Experiment 4. Note that all four identities (*green, brown, white and lilac*), both as coloured discs and as words, were used as stimuli on different trials in all conditions. All conditions were equally likely to begin with a disc versus word. Spacings are not to scale. Colours were shown on a grey background.

Name of Condition	**Example Display**
Adjacent Repetition Same Format	● ● BROWN BROWN
Adjacent Repetition Different Format	● GREEN ● BROWN
Separated Repetition Same Format	● BROWN ● BROWN
Separated Repetition Different Format(A)	● BROWN GREEN ●
Separated Repetition Different Format(B)	● ● GREEN BROWN
No Repetition Format(A)	● WHITE LILAC ●
No Repetition Format(B)	● ● WHITE LILAC
No Repetition Format(C)	● LILAC ● WHITE

Results & Discussion

Trials were screened to determine if participants made any invalid responses (i.e., they pressed a key other than one of the designated response keys), and these trials were excluded from further analysis. Three participants' datasets were excluded due to a high proportion of invalid responses (>25%). For the 17 remaining participants, the average number of invalid responses was low (<.05%). The score for each trial was calculated by summing a 25% portion for each of the four items per trial that were correctly reported in order. Average accuracy for each condition was then computed by taking mean performance across trials for that condition. Proportion correct averaged across the 17 datasets is shown in Figure 5.

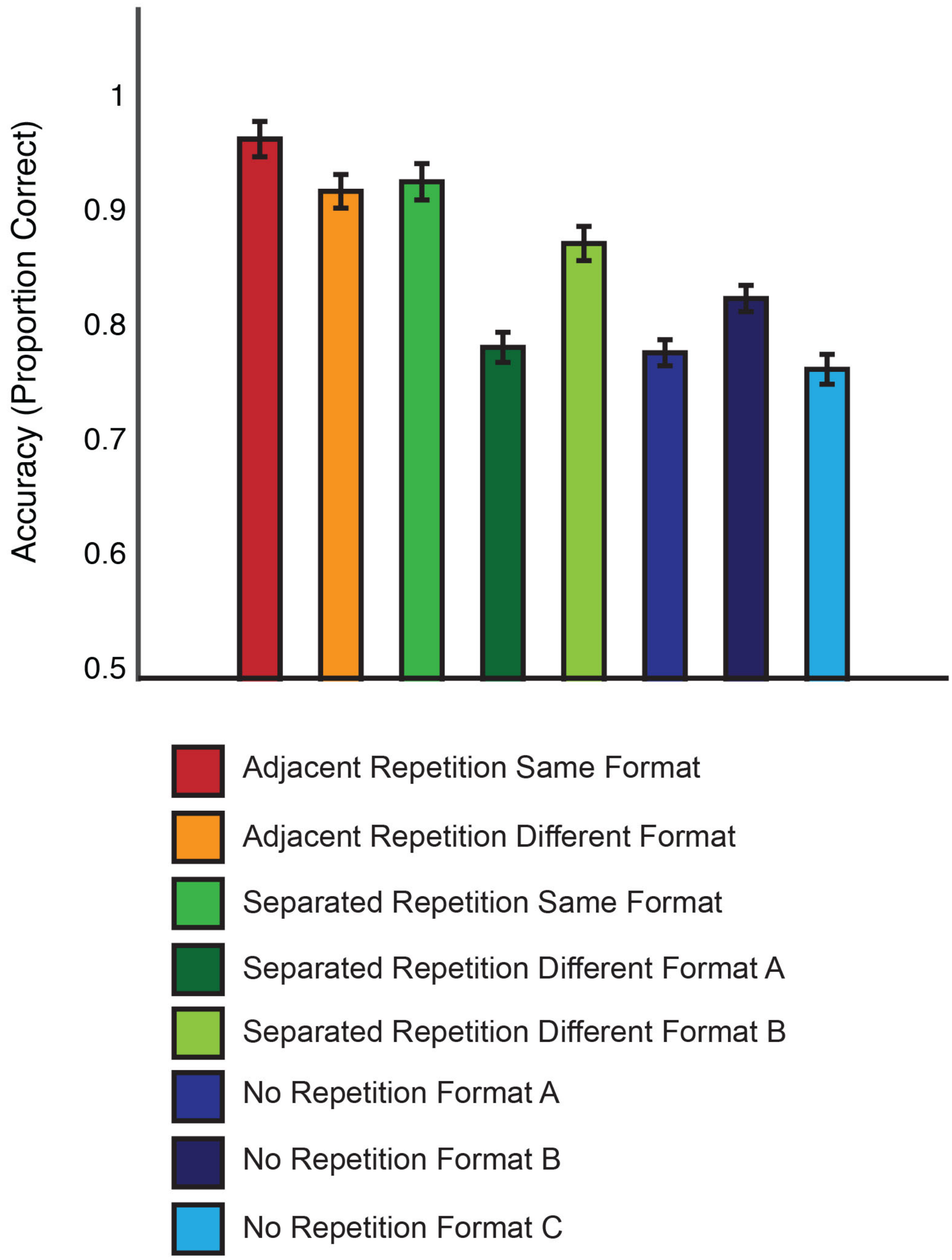

Figure 5. An illustration of the average (proportion correct) accuracy in the eight conditions in Experiment 4. Note that the graph is cut-off at 0.5 performance on the y-axis, rather than zero. Error bars depict standard errors of the mean corrected for within-subjects designs (Cousineau, 2005).

Average accuracy in the eight conditions was submitted to a one-factor ANOVA, where Condition was the independent variable. Mauchly's Test of Sphericity indicated that sphericity was violated (p = .026), and so the Greehouse-Geisser correction was used. This ANOVA revealed a significant main effect of Condition, $F(3.34, 53.47) = 27.43$, $p < .001$, $\eta_p^2 = .632$. As can be seen in Figure 5, performance varied considerably across the different formats. Even in the no repetition baseline conditions, format B produced significantly greater accuracy (.82) than either format A (.77), p = .005, or format C (.76), p = .001, which did not reliably differ from one another (p = .209). This means that the presentation format is an important factor, and therefore, each condition needs to be compared against baseline conditions with the same format. In particular, there seems to be an advantage when the format is such that a pair of discs and a pair of words always appear adjacent to one another – clearly a featural contribution to perception.

The Adjacent Repetition Same Format condition resulted in the highest accuracy (.96), which was significantly higher than its Separated Repetition counterpart (Separated Repetition Different Format B) (p = .001), and significantly higher than its No Repetition counterpart (No Repetition B) (p < .001), indicative of repetition *priming*. The Adjacent Repetition Same Format condition produced greater accuracy than the Adjacent Repetition Different Format condition (.92, p = .015). Thus, when the items were linked by identity but not features, performance was lower than when the items were linked by features. In other words, features had the strongest impact on target perception. But did identity affect performance in its own right? The answer appears to be no, since accuracy in the Adjacent Repetition Different Format condition produced equivalent performance to its separated repetition counterpart, the Separated Repetition Same Format condition (.92, p = .626). That is, when the featural format was equated, identity did not independently impact performance. That said, there was evidence of repetition priming for the Adjacent Repetition Different Format condition relative to the No Repetition Format C (.76, p < .001), however, this was true for most of the conditions, including those with separated repetition. Specifically, the Separated Repetition Same Format outperformed the No Repetition Format C ($p < .001$), and the Separated Repetition Different Format B outperformed the No Repetition Format B ($p = .021$). Only the Separated Repetition Different Format A condition did not exceed that of the No Repetition Format A condition ($p = .748$). Thus, the appearance of repetition priming was not limited to the conditions with adjacent repetition. This means that the evidence of repetition priming in the Adjacent Repetition Different Format condition cannot be treated as evidence for an advantage stemming from repeating the identity of adjacent items.

This was the first experiment in this series to yield evidence of repetition priming, instead of repetition blindness. Presumably the change in format is responsible, however, precisely why it produced this change is not immediately clear. However, what is clear is that having adjacent featurally-identical items impacted perceptual performance, producing a large benefit in target identification accuracy relative to when these same items were rearranged such that the repetition of identity was separated (but the same coupled-disc and coupled-word format was used). In contrast, the evidence appears to suggest that identity information, if contributing at all, was substantively weaker than the contribution due to surface features. However, there was no unambiguous evidence for identity-level information contributing to the formation of object files in the context of repeated items. Rather, any evidence that could putatively reflect identity processing was also susceptible to feature-based explanations. Therefore, this experiment converges with the overarching conclusion from the previous experiments: surface features but not identity contribute to the formation of object files in the context of repetition requiring individuation.

General Discussion

The purpose of the present study was to examine the role of identity-level information, over and above basic featural information about a stimulus, in the formation of object files, and therefore what information is consciously perceived. That is, when the human brain is confronted with rapidly-presented information, what cues does it use to determine what information ought to be grouped into to one object token versus what information reflects multiple objects and therefore requires individuation? A plethora of evidence indicates that surface features, such as colour, luminance, and orientation, influence the formation of object files (Goldfarb & Treisman, 2011a; Goodhew et al., 2015; Hein & Cavanagh, 2012; Hein & Moore, 2012; Hollingworth & Franconeri, 2009; Luiga & Bachmann, 2008; Moore et al., 2010; Richard et al., 2008). In the present work, the goal was to extend on this to determine whether identity-level information plays a similar role. Previous research shows that physical colour information influences the formation of object files in repetition blindness, leading to enhanced perception (Goldfarb & Treisman, 2011b). Here, therefore, the ability of colour *words* to do the same was tested.

Considering the present four experiments together, the results indicate that identity-level information has little or no influence on object file formation and conscious object perception. Surface features eclipse any effect of identity. In Experiments 1, with the words *pink* and *blue,* accuracy in identifying the four items presented on each trial was increased when there was adjacent repetition of different-case same-identity items, relative to when any same-identity items were separated by an interleaving item. Experiment 2 increased the number of possible target options (*pink, blue* and *gold*) but decreased the number of items presented per trial from four to three. In Experiment 2, the factors of featural match versus mismatch and identity match versus mismatch for adjacent items were factorially varied, and a no-repetition baseline was also included. Here, the only condition that did not suffer from repetition blindness was that in which the adjacent items were physically identical. In contrast, when they were not physically identical but instead linked only in terms of identity, repetition blindness occurred – as evidenced by reduced performance relative to the no-repetition baseline. An analysis of the same-identity different-case trials in Experiment 2 revealed that the uppercase and lowercase versions of the word *pink/PINK* were highly featurally similar, such that they produced performance akin to that of the same-identity same-case condition.

Therefore, Experiment 3 was conducted using the same design as Experiment 1, including presenting four items per trial, but now omitting the *pink/PINK* item, instead replacing it with the item *gold/GOLD*. Here the condition in which adjacent items had the same identity but appeared in different cases failed to consistently outperform the two conditions for which repetition was separated, meaning that there was no clear-cut evidence for identity-level processing. Finally, Experiment 4 eliminated the possibility for featural similarity between same-identity different-case items to enhance performance in the Adjacent Repetition Different Format condition, by adding coloured discs as target stimuli. This means that the Adjacent Repetition Different Format could repeat items that were linked *only* in terms of identity (e.g., green disc and the word *GREEN*). Here, surprisingly, repetition priming was observed rather than repetition blindness. However, it was once again identical features, not identity-links that substantively impacted perceptual performance in the context of to-be-individuated repetition. Altogether, the set of four experiments converge on the conclusion that identity information does not make a strong or reliable contribution, if it contributes at all, to perception in the context of repetition, whereas featural cues have a strong and consistent effect.

The conclusion that identity information may not contribute to whether repetition blindness occurs is at first blush inconsistent with the response-efficiency based measures, which have come to the conclusion that identity information is contained within object files (Goldfarb & Sabah, 2016; Gordon & Irwin, 1996). However, one possibility is that these previous results may reflect some featural processing benefitting conditions that were designed to test identity-level processing. For example, Gordon and Irwin (1996) used words in different cases (e.g., *doctor/DOCTOR* versus *bread/BREAD*) in order to assess identity-level processing.

In light of the present study, it is possible that the uppercase and lowercase versions of the same word were sufficiently featurally-similar to promote a feature-based effect, rather than providing a true test of identity-level processing. If so, then the RT-based measures may actually be reconciled with the current perception-based effects. In contrast, it may be that these earlier studies did truly show an influence of identity on response time, whereas the present results indicate that this does not appear to be the case when *perception* (as indicated by unspeeded report accuracy), rather than just speed of response, is considered as the dependent variable. If this is so, then it would be consistent with arguments made elsewhere, that accuracy and response time reflect fundamentally different processes (Prinzmetal, McCool, & Park, 2005).

While identity and abstract conceptual-level information has been found to influence other visual-cognitive processes such as visual attention (Goodhew et al., 2014; Most, 2013; Wyble, Folk, & Potter, 2013), the conclusion that object-file processes are largely impervious to such information actually dovetails with a cognate literature on object perception. As mentioned earlier, the phenomenon of object-substitution masking is conceptualised as reflecting the updating of object files over time, such that masking results when updating of the object file occurs, and a release from the masking occurs when the target and mask are instead individuated as distinct objects (Goodhew, 2017; Guest, Gellatly, & Pilling, 2012; Lleras & Moore, 2003; Moore & Lleras, 2005; Pilling & Gellatly, 2010). Object-substitution masking is modulated by the featural similarity between the target and mask (Goodhew et al., 2015; Luiga & Bachmann, 2008; Moore & Lleras, 2005), and there is an emergent consensus that it is *not* modulated by any form of attentional manipulation (Argyropoulos, Gellatly, Pilling, & Carter, 2013; Filmer, Mattingley, & Dux, 2014; Filmer, Wells-Peris, & Dux, 2017; Goodhew & Edwards, 2016; Pilling, Gellatly, Argyropoulos, & Skarratt, 2014). While identity-level information is implicitly *processed* in object-substitution masking (Goodhew, Visser, Lipp, & Dux, 2011), as evidenced by response-time semantic priming from successfully masked (unseen) targets, the evidence that identity matches between the target and mask modulate *perception* and therefore masking magnitude is less clear. Most studies have found that object-substitution masking magnitude is not impacted by the identity of the target (Chen & Treisman, 2009; Goodhew et al., 2011, but see Experiment 3A in Chen & Treisman). Other studies have either not reported masking as a function of different-identity targets (Reiss & Hoffman, 2007), or have confounded different identity conditions with a guessing bias, making the results difficult to interpret (Reiss & Hoffman, 2006). One recent study has implicated identity-level processing of the target, and its relationship to a task-irrelevant stimulus, in moderating masking magnitude (Goodhew et al., 2016). However, that study did use a relatively small range of possible stimulus items (i.e., 'D', 'd', 'f', and 'F'), and therefore as per Experiment 1 in the present study, it is possible that some low-level featural effects were actually responsible for equivalent performance for same-identity items irrespective of whether they appeared in the same or different case. Future research should test this possibility. Therefore, taken all together, the literature as a whole, in conjunction with the most parsimonious explanation for the present results, implies a model according to which featural similarity modulates object-file formation processes, whereas identity influences attention, but not object-file formation processes, which are impervious to attention. In other words, object-file formation processes occur "earlier" than attention, where identity is relevant.

Historically, it has been very common in experimental psychology for researchers to use letter or word stimuli of different cases to assess identity-level processing (e.g., Clay et al., 2007; Gordon & Irwin, 1996; Marohn & Hochhaus, 1988; Parasuraman & Martin, 2001; Shapiro et al., 1997). The assumption here is that stimuli of different-cases are sufficiently different to distinguish identity from feature processing. The present results challenge this assumption. Instead, it appears that some stimuli are sufficiently similar in their uppercase and lowercase forms to permit feature-based processing, and that this might be particularly likely to occur where the number of possible stimuli employed is small. This means that scientists need to carefully consider how similar stimuli are in their uppercase and lowercase forms before considering them appropriate stimuli for operationalising pure identity processing, dissociable from feature-based processing. In fact, the paradigms used in this study could even provide an empirical test for similarity prior to stimuli being used to answer other research questions.

In conclusion, the visual system employs featural but not identity-level information in determining the formation and individuation of object files. That is, what stimuli look like, rather than what they are, determines whether they are grouped into object files.

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Compliance with Ethics Standards

The author has no conflicts of interest to declare. The author has full control of all primary data, which is available as an electronic file accompanying this submission. It will be placed in an enduring repository upon manuscript acceptance. The Australian National University's Human Research Ethics Committee approved all aspects of the current research protocol, and all participants provided written informed consent prior to participation. All aspects were in compliance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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